DEVELOPMENT OF AN ADVANCED CUTTINGS TRANSPORT FACILITY AND OPTIMIZATION OF WELLBORE HYDRAULICS AT ELEVATED TEMPERATURES AND PRESSURES

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ABSTRACT

Recently, a new research initiative, Advanced Cuttings Transport Study (ACTS), has been undertaken by the University of Tulsa. The ACTS research program calls for the construction of a new research facility, Advanced Cuttings Transport Facility (ACTF), which will allow investigation of cuttings transport with compressible drilling fluids at elevated temperature (200 °F) and elevated pressure (2000 psi). The basic construction of the facility is completed and currently the loop is operational under elevated pressure Modification to the ACTF will continue by adding elevated temperature capability (1999), aeration and foam capability (2000), cuttings transfer capability (2001), pipe rotation capability (2002) and finally, elevation capability (2003). Development and utilization of the ACTF will offer the industry a unique insight into the complex processes that govern fluid flow during drilling and production phases. The Tulsa University ACTS research program will provide valuable information to optimize underbalanced drilling technologies.

INTRODUCTION

Declining US oil production and stricter environmental regulations have resulted in a search for improved technologies to reduce cost and improve recovery from existing hydrocarbon reserves. One of the most effective methods of cost reduction relies on improvements in drilling technologies, in particular, development of directional, horizontal, and multilateral wells. Because many reservoirs in the lower 48 States are partially depleted (low reservoir pressure), to effectively drill re-entry horizontal or multilateral wells, one may have to use aerated drilling fluids (gas assisted, foam, mist, etc.) to minimize formation damage and increase the rate of penetration. Energized (compressible) drilling fluids are also of considerable importance in offshore, deep water drilling to avoid fracturing of unconsolidated formations.

The major advantage of foams and aerated muds is their flexibility in controlling the mud “effective density”, which influences the borehole pressure. Yet, when compared to conventional (incompressible) drilling fluids, very little is known about the hydraulic and rheological properties of aerated drilling fluids and even less is known about their cuttings transport capabilities.

Hole cleaning (cuttings transport) is one of the major factors affecting cost, time and quality of directional, horizontal, extended reach, and multilateral oil/gas wells. Inadequate hole cleaning can result in expensive drilling problems such as pipe sticking, premature bit wear, slow drilling, formation fracturing, and high torque and drag.

The important advantages inherent to drilling with compressible fluids (increased rate of penetration, decreased formation damage, reduced environmental impact, and minimized lost circulation) can be hindered by inefficient cutting transport to the surface.

That is, these advantages depend on understanding the interaction between fluids and the drill cuttings.

Currently, our understanding of this complex interaction is very limited because the vast majority of research in cutting transport has been conducted with conventional drilling fluids. A new research initiative has, therefore, been undertaken at the University of Tulsa to investigate multiphase (gas, liquid and solids) drilling fluid systems for overbalanced and underbalanced drilling operations under elevated temperature and elevated pressure conditions. The purpose of the Advanced Cuttings Transport Study (ACTS) is to determine non-Newtonian fluid characteristics and cuttings transport performance of compressible fluids (aerated mud and foam) as well as conventional (incompressible) and synthetic drilling fluids under elevated temperature and pressure in a large-scale experimental facility.

Development of the Advanced Cuttings Transport Facility (ACTF)

To offer industry new insights into the complex processes that govern multi-phase fluid flow during drilling, the University of Tulsa proposed to develop and construct a large-scale experimental facility. The Advanced Cuttings Transport Facility (ACTF) will allow investigation of the hydraulics and cuttings transport properties of both compressible and incompressible fluids at elevated temperatures and pressures. Furthermore, the "drilling section" will include a rotating drillpipe that will be coupled to an articulated mast. This will make it possible to transport simulated cuttings through an annular space at any wellbore inclination angle with variable drillpipe rotational speeds.

Construction of the ACTF is currently planned through in six phases. Basic design concepts for the new facility and Phase I construction (single-phase flow at high pressure) have been completed. Operational parameters for this phase are pressures up to 2000 psi at ambient temperature utilizing water and various drilling fluids. Key areas of the loop include a rheology section consisting of 2- and 3-inch pipes, and a drilling section consisting of a 6-inch casing and 3 ½-inch drill pipe. Various instrumentation measures flow rate, pressure, and pressure differential.

In 1999, high temperature (up to approximately 200 °F) capability is planned to be added to the basic flow loop (Phase-II). The ability to operate at temperatures higher than 200 °F may be attempted in the future if requested by industry.

Aeration facilities at elevated temperature and pressure is planned to be added to the flow loop as Phase-III.

The cuttings transport capacity is planned for Phase IV. The introduction of cuttings will require some novel approaches with a pressurized loop.

Phase V plans include drillpipe rotation capability. This will be a significant enhancement following the introduction of cuttings into the flow loop to study the effect of drillpipe rotation on cuttings transport.

Current plans extend through Phase VI with the addition of the loop elevation (from horizontal to vertical including intermediate angles) capability. Elevation of the flow loop will have its biggest impact on cuttings transport studies.

Completion of the sixth phase will make it possible to study the flow of compressible drilling fluids and cuttings transport in a full-scale flow loop at pressures up to about 2000 psi and temperatures up to 200 °F; with inclination angles anywhere from 0° to

90°; with and without drillpipe rotation. Figure 1 shows the general configuration of the ACTF. The process and instrumentation diagram of the ACTF is given in Figure 2.

Scope of the Adavanced Cuttings Transport Study (ACTS) Research Program

The specific goals of the proposed project are:

1. Provide the design for and construct ACTF, Phases II through VI, and operate the cuttings transport facility;
2. Conduct studies that will lead to the development of instrumentation to quantitatively determine cuttings location, height, and concentration in the annulus of the drilling section and to measure the bubble size, distribution, and shape during the cuttings transport experiments;
3. Conduct experiments and develop an experimental data-base for cuttings transport under elevated temperature and pressure conditions;
4. Develop models and computer programs for optimization of cuttings transport phenomena at elevated temperatures and pressures.

Successful completion of the study is contingent on accomplishment of several key tasks. Some critical tasks are (but not limited to):

1. The ability to achieve and maintain an approximately constant temperature environment.
2. The ability to handle foams and two-phase flow, and the ability to characterize bubbles.
3. The ability to monitor real-time location of cuttings in an elevated pressure and temperature (EPET) environment.
4. To provide for drillpipe rotation in a pressurized environment.

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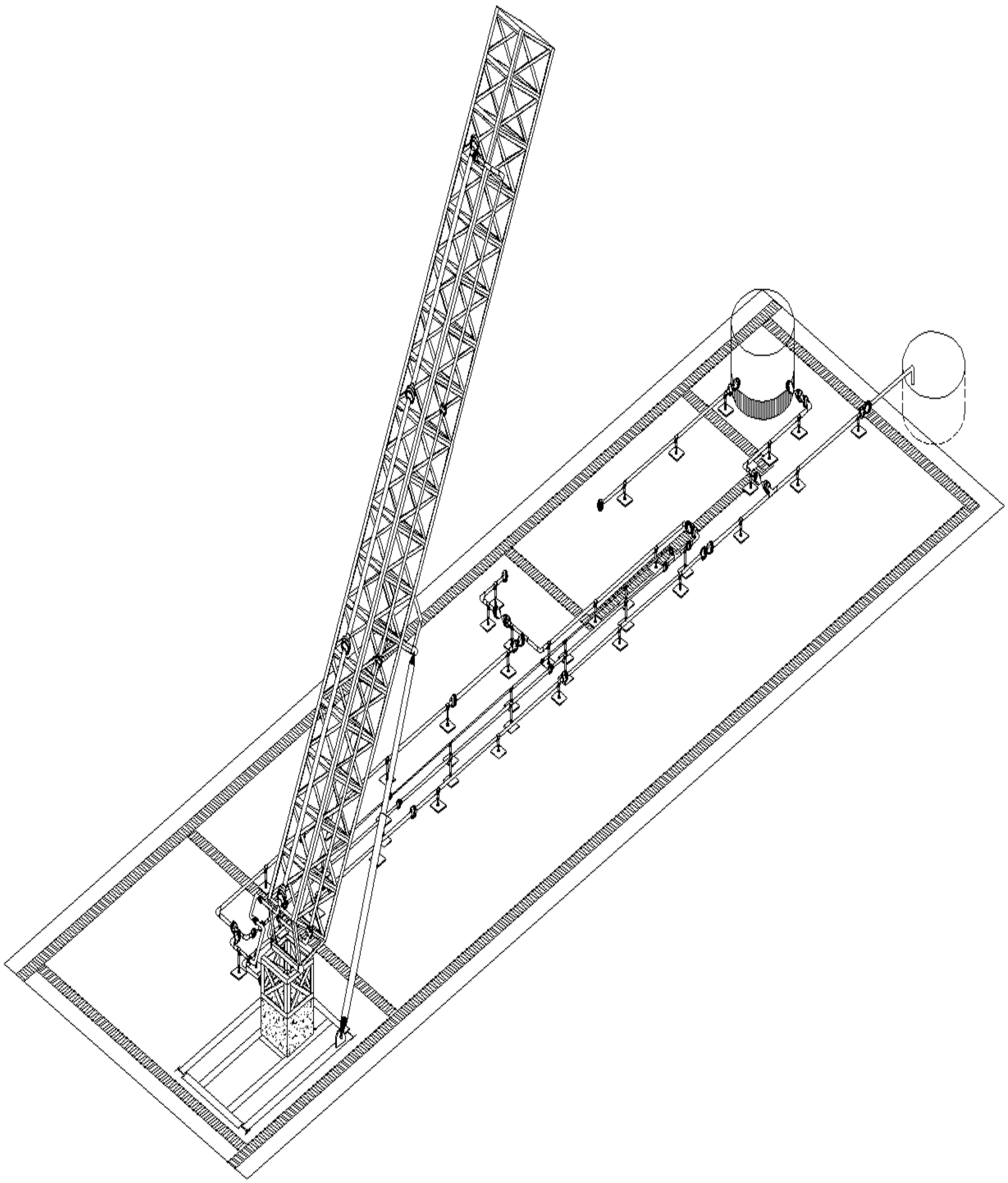

Figure 1 General Configuration of the Advanced Cuttings Transport Facility

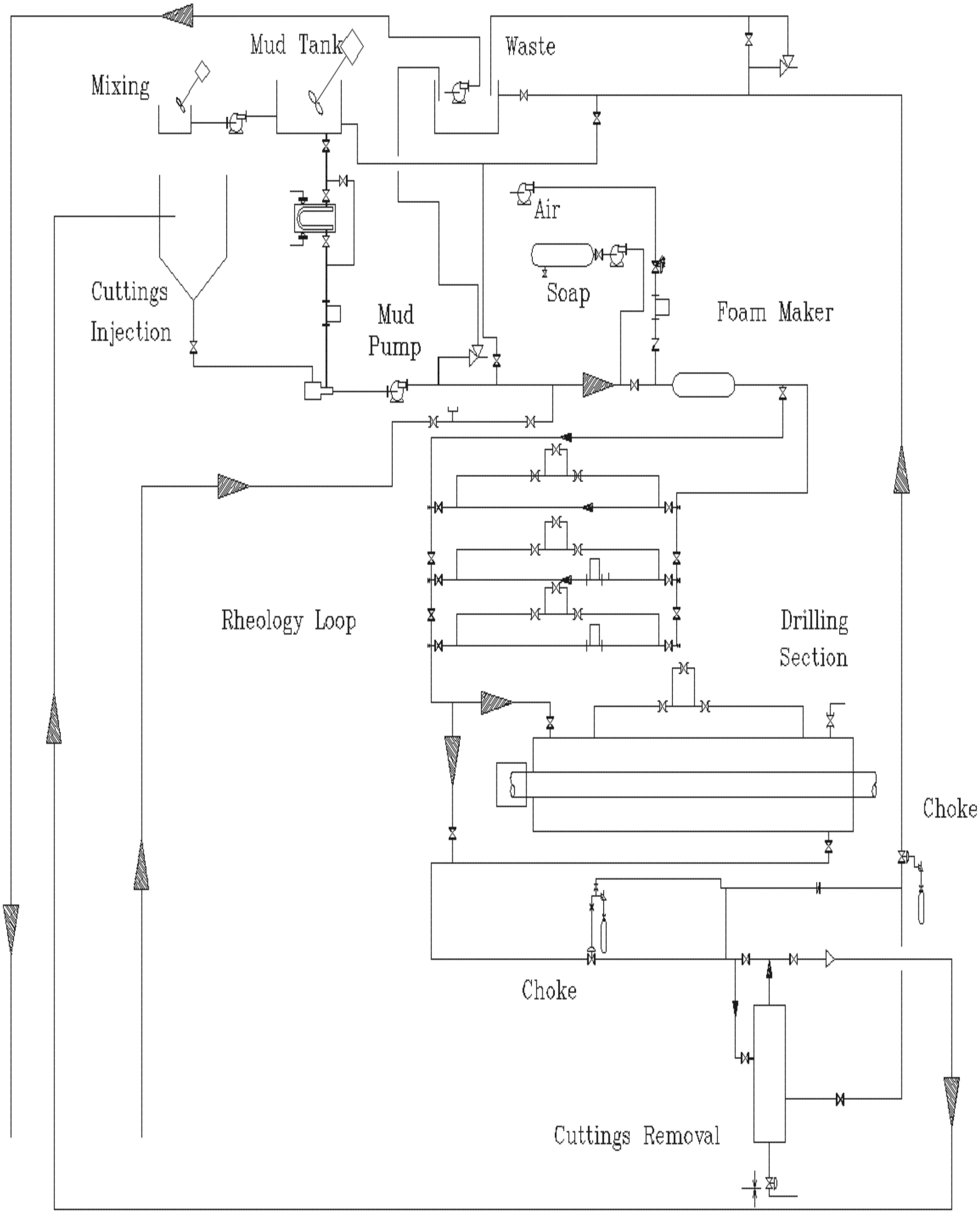

Figure 2 Process and Instrumentation Diagram of the Advanced Cuttings Transport Facility